Thermal Solutions for Photovoltaic Processing Equipment

heaters | sensors | controllers

WATLOW®
Better Thermal Solutions...*Faster*

Thermal Solutions for Photovoltaic Processing Equipment

Rising cost of fossil fuel, changing global demographics, clean energy and new technology is placing the photovoltaic industry in high demand. Because Watlow® designs and manufactures a wide range of thermal solutions specifically for photovoltaic; it is our expertise that allows your product to keep up with that demand. By partnering with Watlow, you can take advantage of a broad selection of thermal components designed to work together for optimal efficiency.

Watlow's thermal solutions start at the beginning with crystal growth and proceed through the manufacturing of the photovoltaic cells and finally through the final assembly and test. Watlow is an innovator of thermal solutions for thin film processing. As an extension of your business, Watlow provides an engineering team dedicated to solving your application requirements as well as superior application support.

Watlow is the world's largest heater, temperature sensor and controller manufacturer with 13 manufacturing facilities and over 40 technical support centers in Asia, Europe and North America. As a global company, Watlow supports international design guidelines and agency approvals. Watlow manufactures thermal solutions that meet agency approvals including RoHS, W.E.E.E, CE, FM, SEMI S2 and UL®. We have hundreds of factory-trained sales engineers and distributors located throughout the world. Our sales engineers are available to complement your team at any stage of your project from concept through prototyping to production.

Heater Solutions

RELIALINE™ Heating System

Watlow's RELIALINE™ heating system is the first modular line heater that can be quickly delivered and easily installed in high performance applications. The RELIALINE heater provides precisely controlled heat distribution and is automatically self regulating to deliver excellent temperature uniformity. The temperature compensation feature allows for the system to increase wattage in cooler regions and decrease the power in warmer zones thus improving the temperature uniformity of the entire line. RELIALINE's ability to self compensate can balance temperature in various areas along the line that traditionally would have needed additional areas of control. This feature decreases the required number of control loops thus decreasing component costs and installation time. This specially designed heating system heats each fitting with the same self-regulating heater materials used on straight lines. Older gas line heaters had size limitations which often meant that the elbows and tees were just insulated. With heated fittings, the RELIALINE greatly increases the temperature uniformity along a line.

RELIALINE heating system

RELIALINE heating system components

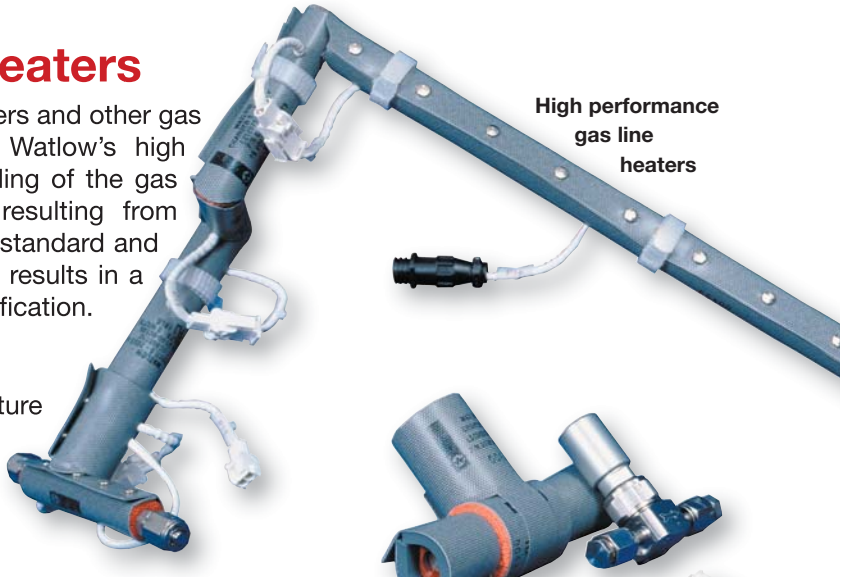
RELIALINE over weldment

Features

- Self regulation saves time and money, decreases the number of control loops and eliminates over-temperature concerns
- Patent-pending modular design provides quick prototype and delivery
- Easy installation of the assembly to a custom gas line
- Temperature-compensating construction adjusts for variations in heat loading yielding improved temperature uniformity
- Temperature uniformity as good as +/- 5°C (9°F)
- Constructed of non-contaminating materials
- Meets SEMI S2 requirements, UL® component recognition pending and RoHS compliant

High Performance Gas Line Heaters

Precision heating of valves, mass flow controls (MFC), filters and other gas line components is critical to process performance. Watlow's high uniformity temperature solutions start with thermal profiling of the gas lines in order to understand the thermal gradients resulting from component mass, material and physical orientation. The standard and custom modeled silicone rubber gas line heater solution results in a thermal system that meets thermal and mechanical specification.



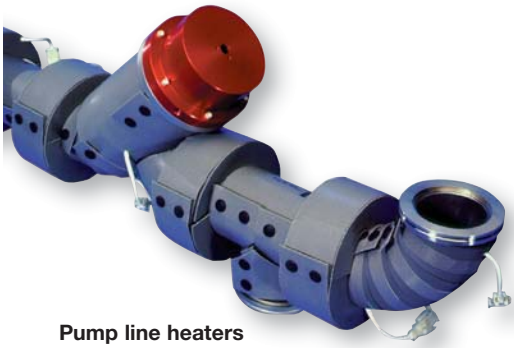
High performance gas line heaters

Features

- Even heating up to 200°C (392°F) for uniform temperature profiles
- Insulated straight fillers for 100 percent line coverage
- Cleanroom compatible silicone rubber construction
- Fire-safe UL® 94-HB or UL®-VO material
- UL®, CE, Semi S2

Heater Solutions

Pump Line Heaters



Pump line heaters

Watlow's pump line heating systems work to reduce buildup of solids in LPCVD, PECVD and metal etch vacuum piping systems. This reduction in buildup helps reduce particle generation and eliminates unscheduled maintenance downtime; therefore, improving the consistency of yields and ultimately saving time and money. Watlow's pump line heating systems are compliant with global guidelines and specifications including CE, NEC, UL® and SEMI S2-93.

Features

- Even heating up to 200°C (392°F) eliminates cold spots
- Modular heating system combines standard parts to cover custom lines
- Easy on-off with reclosable fasteners simplifies installation
- Reinforced silicone rubber fabric used on both heater and jacket
- Precision electronic temperature controllers and software available for changing process requirements
- UL®, CE, NEC and SEMI S2-93 compliant

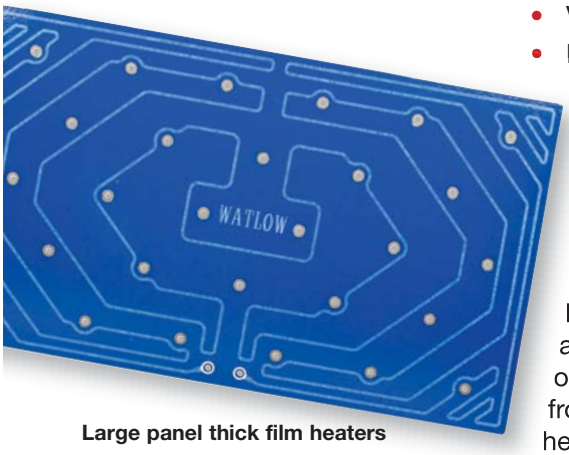
Silicone Rubber Heaters

Silicon rubber heaters

With rugged, yet thin, lightweight silicone rubber heaters you can put the heat where it is needed. Fiberglas-reinforced silicone rubber gives your heater dimensional stability without sacrificing flexibility. Silicone rubber heaters are used in applications for integrated circuit (IC) testing, vacuum chamber wall heating, wet processing dryers and many other photovoltaic applications. The heater can be formed to fit many custom design components within the tool and can be supplied as a thermal assembly to reduce installation costs.

Features

- Designed in the exact shape and size you need to provide easy installation and temperature uniformity
- Agency approvals: c, VDE, CE and RHoS
- Moisture and chemical-resistant material provides longer heater life
- Vulcanizing adhesives or fastener easily bond heaters to your part
- Process temperature up to 220°C (430ºF)



Large panel thick film heaters

Large Panel Thick Film Heaters

Processing requirements for solar panel and display technologies are growing in order to increase throughput and reduce the cost of each manufactured device. In addition to size, new processes require tools that can operate at higher, more accurate and uniform temperatures. By using thick film technology, overall weight of the assembly is greatly reduced. Temperature uniformity and accuracy come from Watlow's ability to precisely pattern and distribute the wattage of a thick film heater circuit and to maintain flatness requirements across a very large surface area. Thick film technology also gives designers the ability to zone heater circuits and reduce potential hot and cold spots resulting from boundary conditions.

Heater Solutions

Large panel IFC heaters

Features

- Large single-piece heater construction provides superior flatness and temperature uniformity
- Material compatible for vacuum applications to 10-6 millitorr
- Operating temperature up to 550°C (1022°F)
- Consistent part-to-part temperature uniformity
- UL® recognized under File E52951

Interference Fit Construction (IFC) Heater Assemblies

Watlow's IFC heated parts are ideal for applications that require materials other than aluminum or exceed the temperature capabilities of cast aluminum. IFC heaters manufactured from alloys such as nickel, stainless steel, Incoloy®, aluminum and copper may operate up to 700°C (1292°F). One of the primary advantages of IFC heated parts over a milled groove approach or a brazed assembly is improved heater life due to the intimate contact of the heater with the substrate. IFC heater assemblies are ideal for physical vapor deposition, transparent conductive oxide and other large photovoltaic equipment applications.

IFC heaters

Features

- Performance up to 700°C (1292°F)
- Materials including Inconel®, 304 and 316 stainless steel and nickel
- Tubular heater element and optional heat/cool tube
- Perpendicularity to better than 0.1 mm
- Flatness to 0.005 mm on 300 mm wafer chuck

FIREROD® High Performance Cartridge Heaters

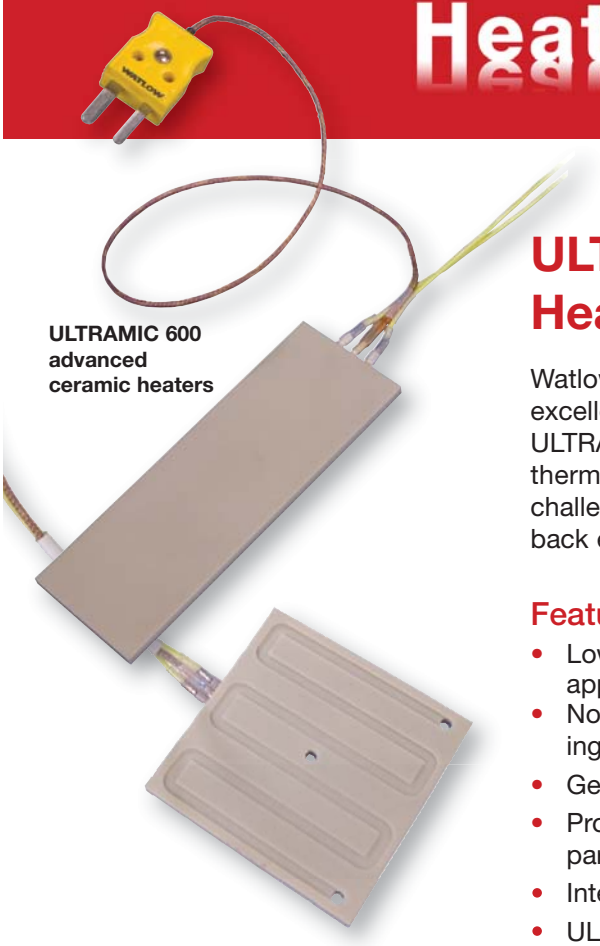
Watlow's FIREROD® high performance cartridge heaters provide superior heat transfer, uniform temperature and resistance to oxidation and corrosion, even at high temperatures. Watlow's applications expertise is used to design special heaters that meet precision photovoltaic equipment specifications including high vacuum and atmospheric applications. Available in both imperial and metric sizes, FIREROD is one of the most versatile and widely used cartridge heaters. The superior construction and operating characteristics of the FIREROD makes it the industry standard.

FIREROD cartridge heaters

Features

- Miniature size down to 3.2 mm (0.125 in.)
- Low mass for better heat transfer and quicker response time
- Swaged construction for higher watt density and process temperature
- Internal thermocouple for space-restricted applications
- UL® and CE approval on most configurations (contact factory for specifics on agency approvals)

Heater Solutions



ULTRAMIC 600 advanced ceramic heaters

ULTRAMIC® 600 Advanced Ceramic Heaters

Watlow's ULTRAMIC® 600 advanced ceramic heaters combine the features of excellent thermal response, high dielectric insulation, high purity and low mass. ULTRAMIC 600 heaters are constructed of aluminum nitride (AIN) and incorporate a thermally matched heating element that provides maximum performance in challenging applications. Advanced ceramic heaters are an excellent solution for back end assembly and test applications.

Features

- Low porosity, homogeneous assembly for atmospheric and vacuum applications
- Non-contaminating heat source resistant to chemical attack and humidity ingress
- Geometrically stable due to low coefficient of thermal expansion (CTE)
- Process temperatures up to 600°C (1112°F) depending on application parameters
- Integrated thermocouple bonded into the assembly
- UL® Recognize File E52951

Tubular heaters

Tubular Heaters

Watlow's round and flat tubular heating elements are high performance metal sheath heaters. Tubular heaters are a proven reliable and robust technology. These heaters are used in both radiant and convection modes to provide uniform temperature profiles. Tubular heaters are available in many sheath materials including aluminum, 316L stainless steel, and Inconel® to meet the compatibility requirements of semiconductor and photovoltaic applications. High temperature tubular heaters are commonly used in heated vacuum chamber assemblies and conveyor ovens.

Features

- Tubular heater sheath temperature up to 870°C (1600°F) depending on sheath materials
- Precision bending for maximum design efficiency and temperature uniformity
- Sheath materials available in aluminum, stainless steel and Inconel®
- High-limit internal thermocouple reduces assembly costs and is more responsive and accurate
- High temperature moisture-resistant seals protect against moisture contamination
- Agency approvals: $_{c}$ℛ$_{us}$, CE and RHoS

Cable Heaters

Watlow's cable heaters are small diameter, high-performance units. This versatile cable heater can be formed to a variety of shapes for high-tech photovoltaic applications. Flat spiral cable heater configurations are the heart of many turnkey cast in and mill groove platen heater assemblies. Coil assemblies are used in physical vapor deposition, chemical vapor deposition and lamination applications. Star wound cable heaters can be used for a variety of nitrogen, air and liquid applications.

Heater Solutions

Cable heaters

Features

- High ductility allows unlimited coiling geometries
- Diameters as small as 10 mm (0.4 in.) to fit in tight spaces
- Low mass for quick response to both heating and cooling
- Process temperature up to 650°C (1200°F)
- 304, 316 stainless steel or Incoloy® for high temperature corrosion and oxidation resistance
- Internal thermocouples for high-limit protection or process control

Nitrogen (N_2) STARFLOW Air Heaters

Throughout many steps in the photovoltaic manufacturing processes, Watlow cable circulation heaters help to improve process time and operating efficiency. Using clean, hot gases reduces wafer drying time. The STARFLOW circulation heater is engineered to heat a flowing gas stream up to temperatures of 760˚C (1400˚F). Because the element is sheathed, the unit can operate in gas streams that require a clean environment, as well as atmospheres that contain contaminants and moisture. Watlow's star-wound cable circulation heater provides extremely efficient and reliable heating.

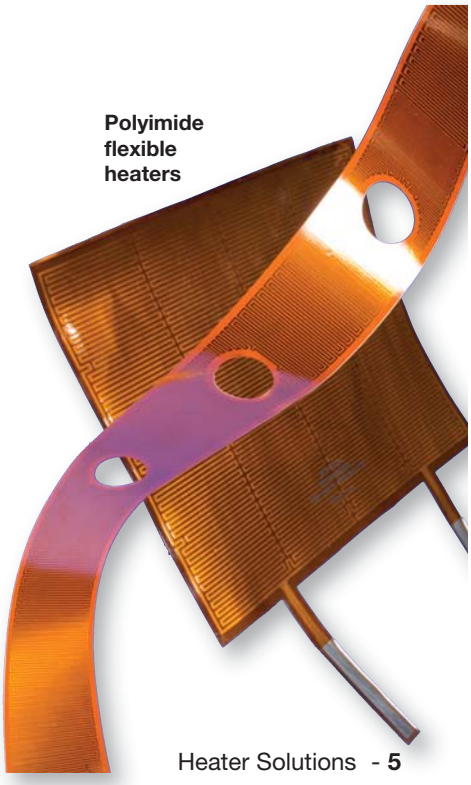
Nitrogen (N_2) STARFLOW air heaters

Features

- Small diameter star-wound heater elements for quick thermal response
- 316L stainless steel heater construction provides pure air streams
- Electro polished steel housing reduces likelihood of contamination
- Integral Type J or K thermocouples for precise control and high limit safety

Polyimide Flexible Heaters

Polyimide is a thin, lightweight organic polymer film that provides excellent tensile strength, tear resistance and dimensional stability. Polyimide heaters are best suited for solar array packaging processes. Polyimide has the additional attributes of low outgassing for vacuum environments and is resistant to radiation, fungus, solvents and many other chemicals. Polyimide has precise temperature distribution, and with the proper bonding or attachment methods to subassemblies can reduce installation costs.



Polyimide flexible heaters

Features

- Excellent physical and electrical properties result in thermal stability
- Process temperature as high as 260°C (500ºF)
- Transparent polyimide material allows inspection of internal details
- Resistant to radiation and fungus, allowing use in a wide range of applications and recognitions
- Custom heater circuit pattern allows for optimized single and multi-circuit designs

Temperature Controllers

Temperature controller consoles

Temperature Controller Consoles

Thermal solutions for gas delivery and pump line heating require precise temperature control. The best process control is achieved through PID temperature algorithms. A turnkey temperature controller console simplifies control and installation of the thermal subsystem. The controller consoles have everything necessary to power and control a gas or pump line including temperature controllers with advanced PID algorithms with CE and UL® ratings, solid state switching and fusing.

Features

- Turnkey integrated control package that is tested and ready for installation
- Advanced PID algorithms for precision temperature control
- Solid state relay (SSR) switching for long life
- Semiconductor fusing to protect system
- Regulatory and testing agencies CE, UL®, UL® 508, FM, SEMI S2 (contact factory for agency approvals that apply to each controller console model)

EZ-ZONE® PM Panel Mount Controllers

Watlow's EZ-ZONE® PM panel mount controller offers control options to reduce system complexity and the cost of thermal loop ownership. The controller is available as a PID controller, an over/under limit controller or these functions can be combined into an integrated controller. Other options include integrated high amperage power controller output with a high-performance PID controller and an over/under limit controller in one space-saving, panel mount package. A number of serial communication options are available to support your connectivity needs including EtherNet/IP™. This controller is available in ⅛ or ¼ DIN panel mount packages.

EZ-ZONE PM panel mount controllers

Features

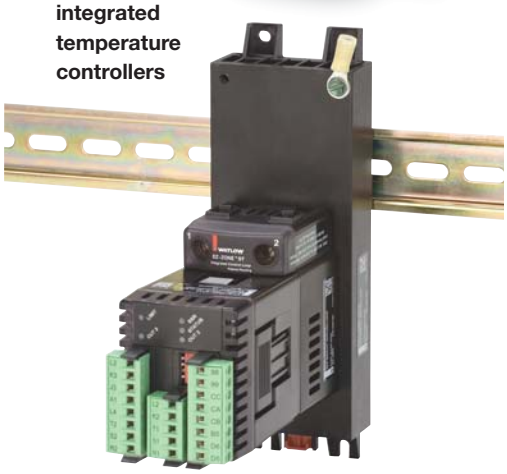
- Advanced PID control algorithm including TRU-TUNE®+ adaptive control
- Integrated PID and limit controller for over/under temperature conditions
- Configuration communications with software saves controller setup time
- Serial communication capabilities provides a wide range of protocol choices including Modbus® RTU, EtherNet/IP™, Modbus® TCP, and DeviceNet™
- High amperage power control output for up to 15 amp resistive loads
- Current monitoring and provides alarm indication of a failed output device or heater load
- Agency approvals: UL® listed, CSA, CE, RoHS, W.E.E.E. FM, SEMI F47-0200, Class I, Div. 2 rating on selected models
- Class I, Div. 2 UL® 1604 rated for use in hazardous locations
- Sealing system complies to NEMA 4X, IP66 for cleaning and washed down
- Touch-safe package increases safety for installer/operator and complies to IP2X requirements
- Ramp/soak programming with four files and 40 total steps

Temperature Controllers

EZ-ZONE ST Integrated Temperature Controllers

EZ-ZONE ST integrates temperature control, power control, safety shut-down and power disconnect in a single package. It features a PID temperature controller already connected to a high amperage SSR with the option of adding a properly sized heat sink, current measurement, and over/under temperature limit, a definite purpose mechanical contactor and digital communications in one package.

The integrated control loop is an excellent solution for photovoltaic and semiconductor applications such as wet processing stations, laminators and IC test and other types of equipment that require precision temperature control while benefiting form space and manufacturing simplicity of an integrated control system.



EZ-ZONE ST integrated temperature controllers

Features

- Back panel or DIN-rail mount
- PID temperature controller with standard and advanced TRU-TUNE+ algorithms
- Compact package and touch-safe package reduces panel size and complies with IP2X
- Sealing system complies to NEMA 4X, IP66 for cleaning and washed down
- Agency approvals: UL® listed, CSA, CE, RoHS, W.E.E.E. FM, SEMI F47-0200, Class I, Div. 2 rating on selected models

SERIES EHG® SL10 Temperature Controllers

Watlow developed the SERIES EHG® SL10 temperature controller for gas line heating applications. This thermal solution includes a compact temperature controller, thermocouple sensor and power switching device that are integrated into the heater's power cord. The SERIES EHG SL10 reduces system costs and substantially extends the life over conventional thermostat solutions.

SERIES EHG SL10 temperature controller configured with a flexible heater

Features

- Pre-wired, in-line controller simplifies installation
- Integral 15 amp switching provides simplifies thermal system
- Tight PID temperature control assures process accuracy
- UL® recognized compliant with agency regulations
- A single controller can be configured with heaters to reduce system cost
- Field upgradable from simple fixed set point control to full featured control with Ethernet/IP™ communications

Temperature Controllers

SERIES D8 multi-loop temperature controllers

SERIES D8 Multi-loop Temperature Controllers

The Watlow SERIES D8 is a powerful controller that combines performance and flexibility with compact design. Compliance with the ODVA™ and Semiconductor SIG standards means this controller is easy to integrate into systems with DeviceNet™ on Controller Area Network (CAN). The four and eight loop versions of SERIES D8 controllers provide complete control solutions for a broad range of applications. Each loop can be individually configured for on-off controller or PID controller. Loops can also be combined to achieve cascade, ratio or differential control.

Features

- PID controller of up to eight loops minimizes panel space per loop and deduces installation time
- Complies with ODVA™ and Semiconductor SIG specifications for DeviceNet™ on CAN
- Menu-guided operation with full text prompts simplify operation
- Cascade controller improves control in systems with excessive thermal lag
- Ratio and differential control algorithms in application in applications with interacting loops
- UL® and C-UL® listed, meet the requirements of the European Community EMC directive and carry the CE mark

DIN-A-MITE power controllers

DIN-A-MITE® Power Controllers

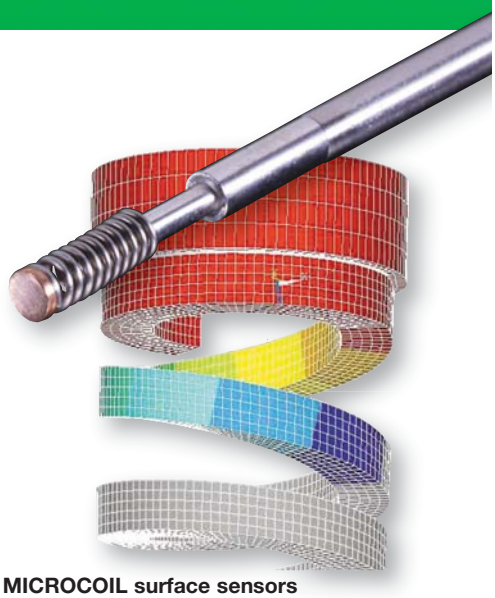
Watlow's DIN-A-MITE® family of solid state power controllers provide silicon controlled rectifiers (SCR) control, heat sink, wiring and touch-safe exterior in one package. DIN-A-MITE with zero cross and burst fire switching is an excellent solution for most current switching applications. DIN-A-MITE is also available for applications with high in-rush such as vertical and horizontal diffusion furnaces that phase fired control.

Features

- Zero cross burst firing for optimum temperature control and reduced electrical noise
- Phase fired controller for systems with high in-rush current
- Integrated power controller for easy installation with no separate components
- Reduced space requirements for power switching components
- Rugged, back-to-back SCR design ensures long term reliability
- UL® 508 Listed, C-UL® Approved, VDE 0160, License #91623 and CE

Temperature Sensor Technologies

Temperature sensor accuracy, repeatability and stability over operating life are critical for photovoltaic processing. Designing the best sensor for an application requires knowledge of material science, thermodynamics, electrical properties, process specification and connectivity. Watlow's advanced sensor technologies and understanding of the application gives us the capability to design sensor assemblies that support new innovations in cell processing. Thermocouple, RTD and thermistor sensor assemblies are specially designed to ensure precise and repeatable temperature characteristics.



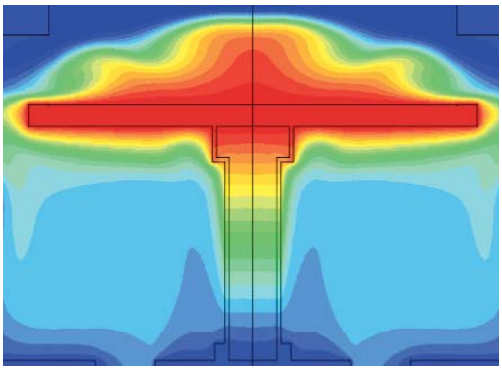
MICROCOIL surface sensors

Features

- Isothermal design increases temperature response and accuracy
- Repeatable and traceable to U.S. National Institute of Standards and Technology (NIST)
- Interchangeably allows probes from different lots to be substituted without recalibration
- Small size and low mass enables very fast response to small changes in process temperature

Design Services

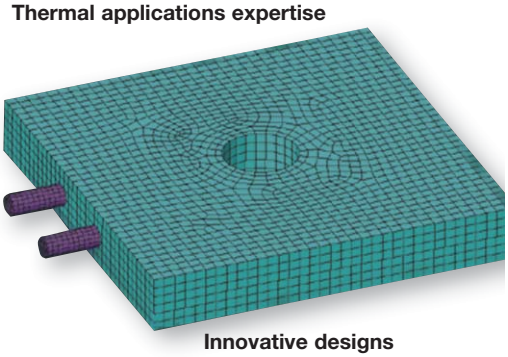
The complexity of photovoltaic tool designs and processes combined with economic reality has created an environment where businesses need to identify and focus on their core competency while partnering with companies that have complementary skills. Watlow's core competency is thermal applications expertise and delivering innovative designs for complex thermal challenges. Thermal applications expertise as a core competency is the ability to understand system thermodynamics and photovoltaic process requirements. In addition to thermal expertise, Watlow has a project management expertise that has proven to accelerate projects and deliver a working model on the first iteration.



Thermal applications expertise

Features

- Conceptualizes, designs and validates thermal systems
- Reinforcing your market position with innovative, patentable designs
- Offers insight into emerging heating, sensing and control technologies
- Provides the expertise to reduce the development risk and improving time to market
- Employs computer modeling techniques including finite element analysis (FEA) and computational fluid dynamics (CFD) to simulate thermal system performance
- Provides complete 'production-ready' drawing packages
- Provides objective 'peer-reviews' of submitted designs



Innovative designs

WATLOW®

Better Thermal Solutions...*Faster*

Find out more about Watlow and how we can provide thermal solutions for your company:

By phoning us: 1 . 800 . WATLOW2

E-mailing us: info@watlow.com

Or visiting our website: www.watlow.com

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About Watlow

Watlow Electric Manufacturing Company (Watlow) designs and manufactures industrial heaters, temperature sensors, controllers, system assemblies and software – all of the components of a thermal system. Designing and manufacturing the complete thermal system allows Watlow to recommend, develop and deliver the optimum thermal solution for our customers' equipment and process heat requirements.

Watlow manufactures thermal systems for a broad range of industries including but not limited to: semiconductor processing, photovoltaic, aerospace, analytical instrumentation, medical equipment, packaging, foodservice equipment and plastics processing. Watlow customers receive the highest level of technical engineering combined with exceptional customer service.

Since 1922, Watlow has grown in product capability, market experience and global reach. We hold more than 140 patents and employ 2,000 employees working in 13 manufacturing facilities in the United States, Mexico, Europe and Asia. We also have sales offices in 17 countries around the world. Our company has grown at an exponential rate but our commitment remains the same – to provide our customers with superior products and services for their individual needs.